

Use of ERTS Data for a Multidisciplinary Analysis
of Michigan Resources

ERTS-1 Project 321
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Introduction

ERTS project 321 is organized into three tasks, each with its own principal investigator; (1) Forestry, Dr. Wayne Myers; (2) Agriculture, Dr. Gene Safir; and, (3) Soils and Landforms, Dr. E. P. Whiteside. Due to similar phenology and overlapping test areas, efforts in the agriculture and forestry tasks have been closely coordinated. However, the soils and landforms task is being conducted separately. The project includes two subcontracts with the Environmental Research Institute of Michigan. The objectives of the first subcontract are to apply standard multispectral recognition processing procedures to ERTS-1 multispectral scanner data and related airborne MSS underflight data, and to assist MSU personnel in the analysis and interpretation of recognition maps and other extracted information in working toward the goals of the prime contract. The purpose of the second subcontract is to develop new techniques for estimating the proportions of unresolved materials in individual resolution elements by use of multispectral scanner data. Material from the subcontractor's Type II progress report to M. S. U. is incorporated in the main body of this report.

General Review of Progress During First Two Reporting
Periods (August, 1972 - November, 1972)

Both collections of ground truth information and aircraft underflights were initiated prior to satellite launch.

Techniques of collecting ground truth information have been somewhat different for the three tasks. Interpretation of underflight imagery has provided the primary source of ground truth information for the forestry task, with supplemental field reconnaissance being done as needed. Direct field observation and 35-mm photography have been used as the main sources of ground truth information for the agriculture task. Specifically, biological parameters such as plant height, row directions and width, percent ground cover, corn tassel color, and disease incidence were estimated and recorded for numerous selected fields in the test area. For the soils and landform task, the primary sources of ground truth information have been maps and airphoto interpretation. Cooperators in both the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service and the Forest Service have also contributed to the pool of ground

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truth information. The A.S.C.S. efforts have produced a set of annotated copies of enlarged airphotos showing the location and nature of vegetation types on the holdings of landowners who subscribe to A.S.C.S. programs.

The program of underflights originally scheduled was completed. This included RB-57 flights over the extensive test area on June 10, 1973 and September 5, 1973, and periodic C-47 flights with the Michigan aircraft over selected intensive test areas during the growing season. However, the combination of lake satellite launch and inclement weather conditions produced only one usable frame of ERTS-1 data during Michigan's growing season (E-1033-15580 taken on August 25, 1972). Therefore, it may be necessary to request supplemental underflights early in the 1973 growing season.

The receipt of bulk 9 x 9 ERTS-1 transparencies is currently running about one month behind date of collection. However, no precision composites have yet been received of any ERTS-1 frames over Michigan. Computer compatible tapes for the August 25th ERTS-1 frame were not received until December, 1972. Since the original data requests for photographic imagery were cut back by N.A.S.A., it has been necessary to develop a local classification and information retrieval system to maximize the utility of the available imagery among the several tasks and subcontract personnel.

Preliminary analysis of the bulk 9 x 9 -inch transparencies indicates that photointerpretation efforts will be much more successful on the precision composites than on bulk imagery. Different vegetation, soil, hydrological, geological, and cultural features show differently in the four bands, making compositing necessary for accurate identification. Band 4 shows faint highway patterns and wooded bands along waterways, but no feature is resolved particularly well in band 4. Band 5 is the best single band for interpretation of forest vegetation. Large woodlots (80 acres or more) are distinguishable, as are linear bands of trees along watercourses. Forest vegetation registers in dark tones in band 5. Expressway networks are clearly defined in band 5, appearing in light tones. The appearance of water bodies in band 5 is variable. For example, Lake Lansing appears in very dark tones and could be easily misinterpreted as a large wooded area. In contrast, Gull Lake in Kalamazoo County is barely distinguishable.

Band 6 shows water bodies very distinctly in dark tones. Neither highway patterns nor forested areas register in this band. Agricultural field patterns are visible in band 6, but bare fields could not be separated from crop cover on the bulk transparencies. Because most bare fields were less than 20 acres in size, soil patterns and landforms could not be identified. Large, cultivated organic areas could be identified because of the great contrast between the crops and the dark, organic soil. The appearance of features in band 7 is very similar to that in band 6.

A composite of either bands 5 and 6 or bands 5 and 7 would appear to offer good potential for interpreting and distinguishing forest vegetation, agricultural field patterns, water bodies, and major highways or urban areas.

Since it is very difficult to superimpose 9 x 9 bulk transparencies in an interpretable fashion or to construct maps graphically from the skewed images, those phases of the investigations which involve photointerpretation have been suspended pending the receipt of rectified color composites.

Progress Since Last Reporting Period (December, 1972;
January, 1973, and February, 1973)

As explained above, photointerprative analysis have been set aside pending receipt of precision color composites. Attention is now being concentrated. digital computer analysis of data on magnetic tapes from ERTS frame E-1033-15580 taken on August 25, 1972. As explained previously, this is the only cloud free frame obtained over the Michigan test sites during the 1972 growing season.

Digital tape data for Frame 1033-15580, 25 August 72, were received by MSU from NASA and delivered to ERIM on 3 January 73. These data were screened for quality by some preliminary processing on the ERIM digital computer. They were found to exhibit the same problem found in a set of tapes for the same frame received by ERIM under another contract. The problem is that one of six detector elements which generate the MSS data in ERTS Band 6 (0.7-0.8 um) was faulty, and anomalous data are present for Band 6 in every sixth line of data; otherwise, the data appear to be satisfactory. This problem complicates signature extraction and data analysis and, for some purposes, will restrict recognition processing to three channels.

The primary test sites were located within the digital data, and line-printer maps were produced for ERTS Band 5 (0.6-0.7 um). These maps were used by MSU personnel to locate selected training and test plots of known ground cover. ERIM personnel then designated these plots by line and point number to the computer for extraction of signal statistics, with care being taken to avoid boundary points. The small size of many of the fields and forest stands complicates the extraction and analysis of signature statistics and the designation of test plots.

Agriculture-Forestry Task

For the Agriculture-Forestry task, 58 plots were designated and ERTS signal statistics were extracted for eight types of ground cover. These statistics were subjected to cluster analysis; several plots were selected, and their statistics combined to form various recognition signatures. For this report,

the selected plots are called training sets, while the remainder are called test sets. The "test" designation is not completely appropriate since the signal statistics of these plots were analyzed in the selection process; however, independent test plots are to be selected and analyzed later.

Recognition maps were produced for the intensive test area with several different parameters and three ERTS MSS channels (ERTS 6 was excluded). First, twelve recognition signatures were used (See Table I) and maps were produced for seven classes with different rejection threshold levels, that is, each observation was classified as belonging to one of the recognition signatures and then tested to see if it should be rejected and categorized as belonging to none of the classes considered. Next, seven recognition signatures were used for six classes. The seven recognition signatures included combinations of the pairs of signatures used for several classes in the twelve-signature runs. A new class for senescent or senescing vegetation was formed after consultation with MSU personnel; this class is discussed in greater detail in a later paragraph where results are presented.

The recognition maps were forwarded to MSU personnel for analysis and interpretation. Concurrently, a computer analysis of results in the 58 plots was undertaken at ERIM.

The overall results of the first-look analysis of recognition in the Agriculture-Forestry area are summarized in Table II for the seven-signature, six-class recognition run with a rejection threshold probability of 0.001. As noted earlier, only three ERTS channels were used (4, 5, and 7). The values in Table II represent averages of percentages computed separately for each plot analyzed. The overall percentage of correct classification is nearly 83%. The average percentage error is 10.5%, with 17% being Type I (i. e., missed classification, including not classified) errors and 4% being Type II (i. e., incorrect classification) errors. If "not classified" points are excluded from the computation, the overall average is 86% correct.

Recognition percentages are high for those vegetation classes that had mature and uniform canopies at the time the data were collected (Aug. 25th). Corn, soybeans, alfalfa, and trees met this criterion, and were accurately classified, although only one alfalfa field was analyzed. The class of senescent or senescing vegetation included observations from field beans (11 fields), wheat stubble (4 fields), and grass (1 field). These canopies were characterized by non-uniform distributions of dead and dying vegetation along with some patches of more healthy vegetation.

For example, field beans had matured and begun senescing, while soybeans and corn were more vigorous. Also, wheat stubble fields were dry and

TABLE 1. RECOGNITION SIGNATURES USED FOR PROCESSING

A. Twelve-Signature, Seven-Class Runs

Class	Signature	No. Training sets
Corn	Corn-A	3
	Corn-B	2
Soy	Soybeans-A	2
	Soybeans-B	2
Tree	Trees-A	2
	Trees-B	2
Bean	Field Beans-A	2
	Field Beans-B	2
Alf	Alfalfa	1
Gras	Grass	1
Soil	Soils-A	2
	Soils-B	2

B. Seven-Signature, Six-Class Runs

Class	Signature	No. Training Sets	No. Test Sets
Corn	Corn	5	16
Soy	Soybeans	4	3
Tree	Trees	4	5
Alf	Alfalfa	1	0
Senesc	Field Beans	4	
	Grass	1	11
Soil	Soils	4	0

brown except for some that had been seeded to alfalfa or red clover; these latter fields had patches of green growth among the stubble. The wide variability within these vegetation types at this time of year makes it difficult to accurately classify them then. Bare soil was distinctive and accurately recognized. However, no test fields were in the data set analyzed, so a definite conclusion should not be drawn yet.

The first-look analysis for computer recognition shows a good capability for differentiating each type of vegetation that had a dense green canopy. Bare soil was also recognizable as a category. However, recognition was difficult in senescing or senescent vegetation.

The next step in the analysis of computer recognition is a more critical evaluation of accuracy by cover type for all resolution elements in selected portions of the frame. The following discussion presents an example of this kind of evaluation for forest cover.

Figure 1 is a portion of the gray map for ERTS channel 5 in Chester and Roxand Townships of Eaton County, Michigan. Figure 2 shows this same gray map with the major roads delineated.

In Figure 3 an RB-57 color infrared photo has been used to shade in the actual locations of woodlots. A total of 812 resolution elements in Figure 3 fall in the shaded forest area. Figure 4 shows a computer recognition map of this same area based on analysis of the data in channels 4, 5, and 7. The cover types which the computer was programmed to recognize are corn, soybeans, trees, field beans, bare soil, and alfalfa. The computer was forced to choose one of these areas. In other words, there was no residual category for unrecognized elements. Figure 5 shows the same recognition map as Figure 4, with an X marking each element associated with forest cover which was misclassified. Only 16 elements outside the woodlots were classified as forest or "trees," and these are probably due to small patches of trees. However, 290 of the 812 woodlot elements (36%) were not classified as trees. Most of these elements were situated on the border of woodlots or in sparsely stocked areas. For the most part, these border elements were classified as corn. Since the original "trees" training sets were located in the center of dense woodlots, the misclassification of border elements is not too surprising. As indicated in previous tables, accuracy of classification on "test" elements taken from the center of woodlots is on the order of 90%.

The logical follow-up to the analysis discussed here is to form a new "sparsely stocked forest" training set from these border elements that were omitted from the "trees" category. The subresolution element analysis to be performed under the second ERIM subcontract should also furnish increased accuracy on these border elements.

Similar evaluations to the one presented for forests will also be performed for the other cover types, and analytical procedures will be modified according to the results of these evaluations.

Special Considerations in the Soils and Landforms Task

Due to adverse weather conditions, the August 25 ERTS frame was the only one available for analysis of soils and landforms as well as vegetation. On August 25 vegetation covers most of the soil, a condition which is not very satisfactory for identifying soils and landforms. Data collected later in the year (October) would have been more satisfactory for these analyses. Spring (May 15 to June 15) is also a satisfactory time (perhaps the best) for collecting remote sensing data on soils and landforms. During the spring much of the soil is bare or has a sparse vegetative cover.

Bare, mineral soil areas were identifiable on the channel 5 (0.6-0.7 m) gray scale map prepared from the computer compatible tape. About 5 percent of the area had bare soil.

For the soils and landforms task, ERTS signal statistics were computed for eight plots and combined to form four signatures. The signatures represent (1) poorly drained, medium texture soils, (2) poorly drained, organic soils, and (3) and (4) well drained soils from two different areas. A relatively quick assessment of our ability to use the computer to recognize soils in the soils test site was desired. Therefore, recognition maps for different rejection thresholds were produced with only the four soil signatures used in the computations. These maps were forwarded to MSU personnel for preliminary analysis and interpretation, but no parallel computer analysis effort was initiated at ERIM.

All bare soil areas in a portion of the ERTS-I frame processed were recognized correctly on these maps, but considerable misclassification of soils also occurred in those areas. Some large fields of well-drained soils were misclassified as somewhat poorly drained and poorly drained soils. Also, somewhat poorly drained and poorly drained soils were misclassified as well drained soils.

A frequently observed phenomenon in bare, well drained soil areas was the correct classification of well drained soil in the center of the field and the misclassification of somewhat poorly drained and poorly drained soils around the edge of the field. This misclassification may be the result of the resolution elements covering a portion of the bare field and a portion of the adjacent, vegetated field.

Bare, organic soil areas were separated from bare, mineral soil areas. Water and some forest vegetation were misclassified as organic soils.

This classification and other false recognition were reduced significantly in a subsequent recognition map prepared with a greater probability of rejection. This map had very little change in the recognition of soils within bare fields. Landforms could not be identified from patterns on the four gray scale maps nor from patterns on the recognition map.

In addition to the processing of ERTS data, multispectral scanner data collected by the Michigan C-47 aircraft on October 19, 1972 for test site III were processed to simulate ERTS-1 data. Video images of these bands were produced by the SPARC. A two channel ratioing technique was employed in an attempt to enhance differences within bare areas, within vegetated areas and across bare and vegetated areas. The channels ratioed included those which represent the ERTS-1 channels. The ratio technique did not provide any additional information than that which was available from color imagery obtained at the same time as the scanner data.

ERTS-1 Channels

4
5
6
7

Simulated ERTS-1 Channels

0.50-0.60 um
0.62-0.70 um
0.67-0.90 um
1.0 - 1.4 um

Ratios of channels observed were as follows:

0.50-0.60 um/0.62-0.70 um = 4/5
0.62-0.70 um/0.67-0.90 um = 5/6
0.62-0.70 um/1.0-1.4 um = 5/7
0.67-0.90 um/1.0-1.4 um = 6/7
8.0-9.1 um/8.7-10.7 um
1.0-1.4 um/2.0-2.6 um
2.0-2.6 um/8.7-10.7 um
0.33-0.38 um/8.7-10.7 um
0.58-0.64 um/0.62-0.70 um
0.50-0.54 um/0.55-0.60 um
0.33-0.38 um/0.41-0.48 um

Plans for Next Period

The computer analysis of ERTS data on magnetic tape will be continued during the next reporting period in all tasks.

Since the computer tapes have only been available since late December and the receipt of precision color composites is still uncertain, we feel that specification of a detailed plan of work for the remainder of the project period would be premature at this point in time.

TABLE II. SUMMARY OF RECOGNITION RESULTS ON A PLOT-BY-PLOT BASIS FOR 58 PLOTS, ERTS FRAME 1033-15580 (6 CLASSES, 7 SIGNATURES, 3 CHANNELS (ERTS 6 EXCLUDED), EVERY 6TH LINE DELETED, 0.001 PROBABILITY OF REJECTION)

Table II A.

Class	No. Plots	No. Points	Average Percentage of Class' Plots Assigned to Listed Recognition Signature						
			Corn	Soy	Alf	Tree	Senesc Bean	Grass	Soil
Corn	21	481	84.27	0.55	0.13	9.85	3.85	1.35	0
Soy	7	96	1.43	85.72	3.42	3.81	3.83	0	0
Alfalfa	1	12	0	0	91.67	0	0	0	0
Trees	9	288	11.95	3.52	0	83.95	0.19	0.39	0
Senesc	16	306	17.30	7.78	10.01	0	50.72	9.78	3.30
Soils	<u>4</u>	<u>56</u>	0	0	0	0	0	0	91.67
TOTALS	58	1239							

Table II B.

Summary of Percentages (Averaged Over Plots)							
Class	No. Plots	No. Points	Not Clas'd	Correctly Assigned To Class	Incorrectly Assigned To Class	Average Error	Correct, Excluding Not Clas'd
Corn	21	481	0	84.27	9.04	12.38	84.27
Soy	7	96	1.79	85.72	2.94	8.61	87.28
Alfalfa	1	12	8.33	91.67	3.28	5.18	100.00
Trees	9	288	0	83.95	4.19	10.12	83.95
Senesc	16	306	1.11	60.50	3.52	21.51	61.17
Soils	4	56	8.33	91.67	0.98	4.65	100.00
Averaged Over All Classes			3.42	82.96	3.99	10.51	86.11

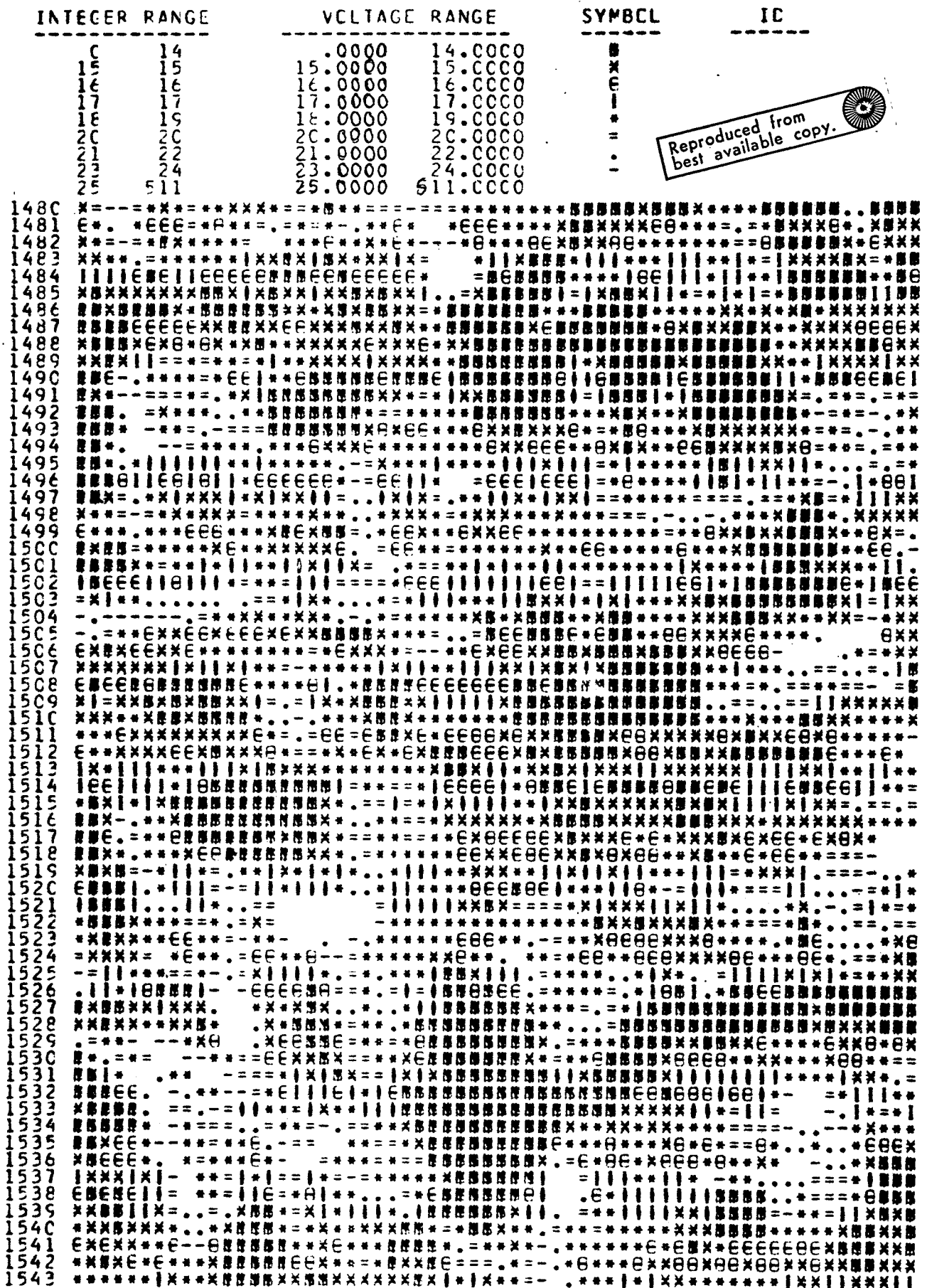


Figure 1. Channel 5 gray map for portions of Chester and Roxand Townships in Eaton County, Michigan.

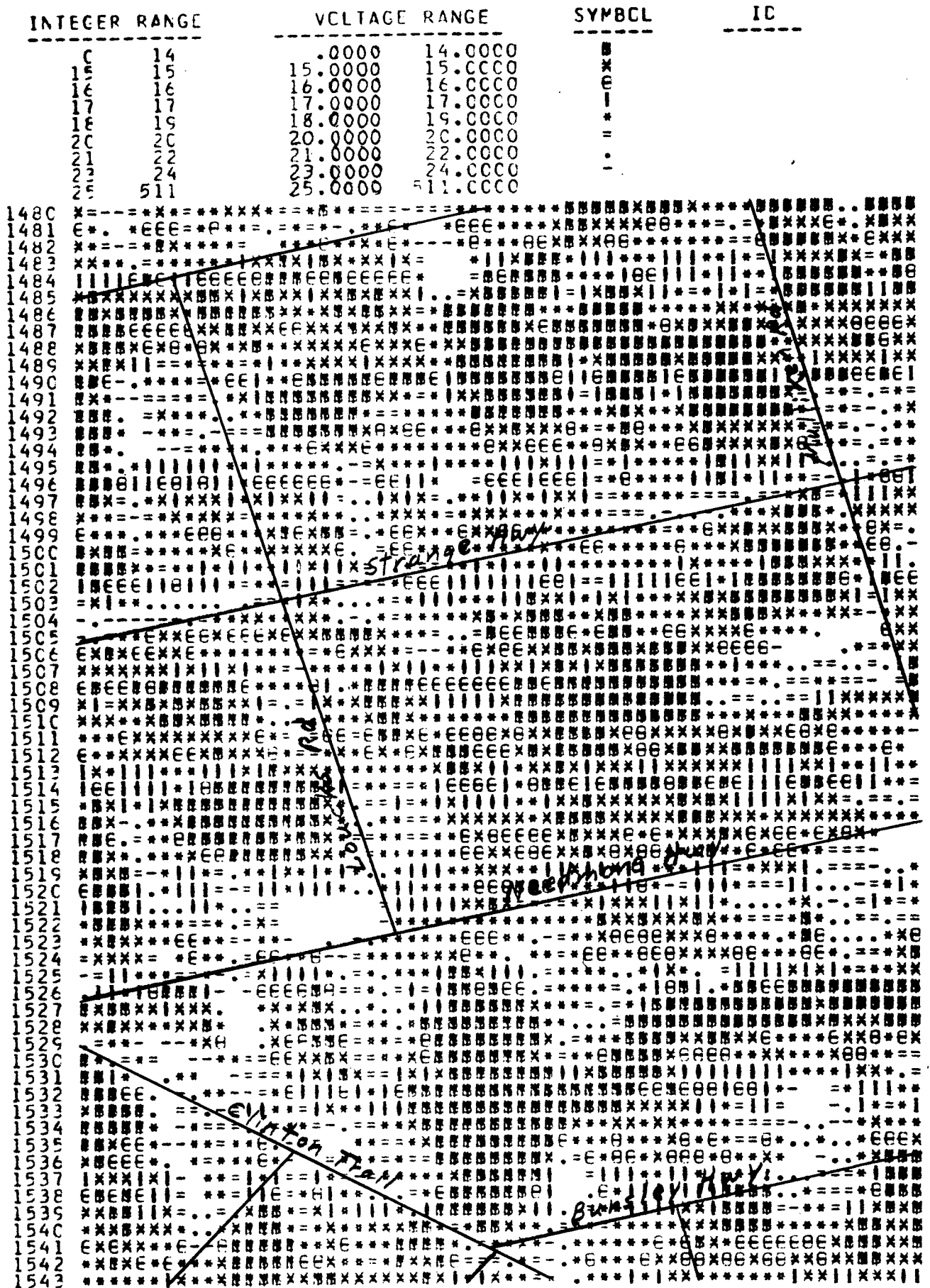


Figure 2. Channel 5 gray map for portions of Chester and Roxand Townships in Eaton County, Michigan with major roads delineated.

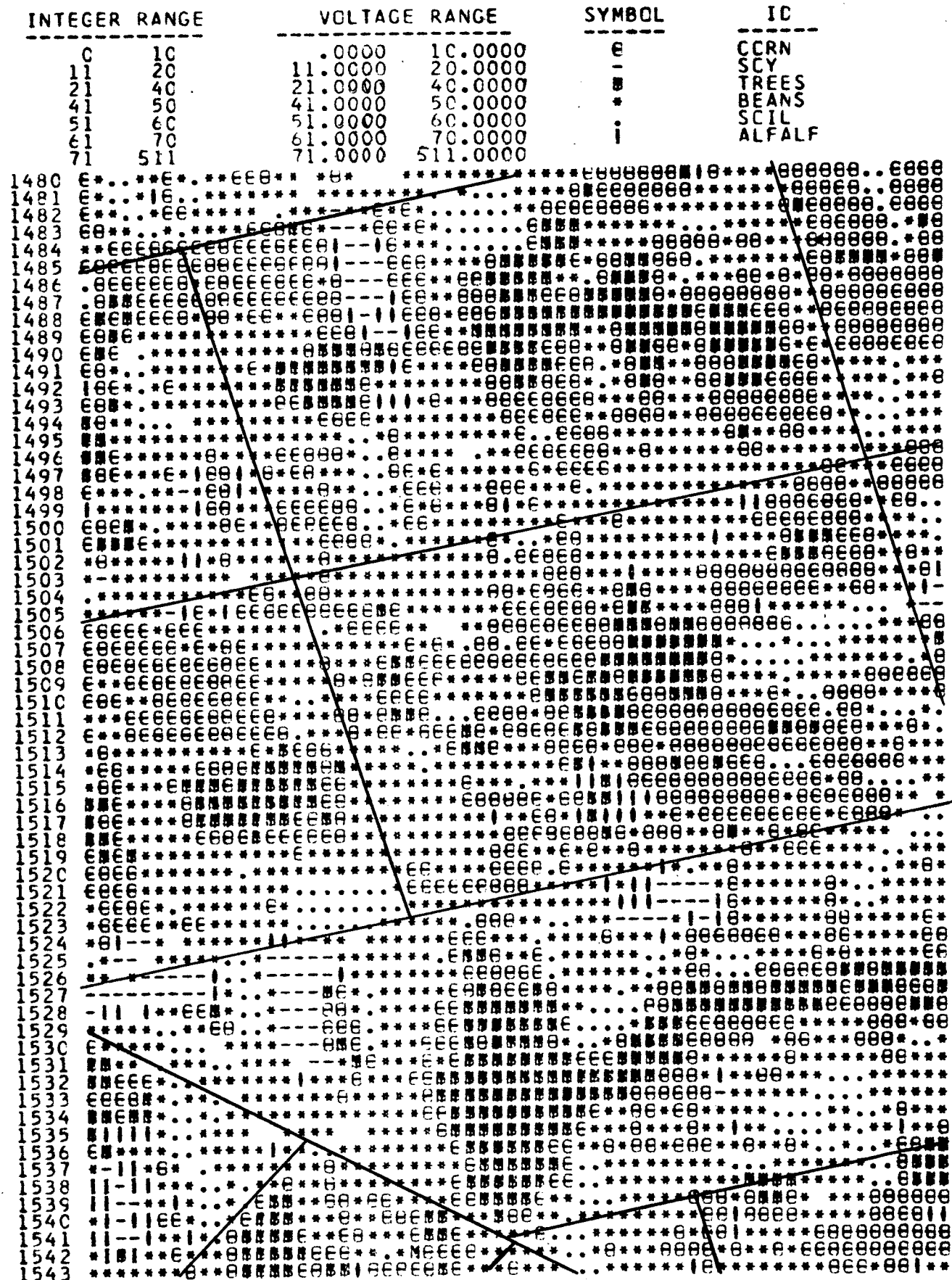


Figure 4. Six-category computer recognition map for the area shown in figures 1 - 3.

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